Clemson IPM Program Newsletter

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Integrated pest management is an ecologically-based approach to managing pests with an emphasis on using multiple management strategies. The principles of IPM can be applied to any pest of food or fiber production systems, landscapes, and urban environments. IPM considers multiple control tactics with the aim of minimizing selection pressure on one given tactic.

The Clemson IPM program (https://www.clemson.edu/extension/ipm/index.html) seeks to increase adoption of IPM practices in South Carolina by developing interdisciplinary, research based information, and providing it to the public in efficient and accessible formats. The goals of the IPM program are driven by the needs of stakeholders, who have an integral part in developing the priorities of the current program.

The Clemson IPM Newsletter will provide updates on research, extension programs, successes in IPM, important dates, and more!

@IPM_Clemson

Follow the Clemson IPM program on Twitter for real time updates throughout the growing season

Meet the Team

The IPM program at Clemson is comprised of the coordination team, extension personnel, and researchers throughout the state.

Pee Dee REC
Francis Reay-Jones, *Field Crop Entomology*
JC Chong, *Specialty Crop Entomology*
Joe Roberts, *Turfgrass Pathology*
Ben Powell, *Pollinator Specialist*

Coastal REC
Tony Keinath, *Vegetable Pathology*
Matt Cutulle, *Vegetable Weeds*
Brian Ward, *Organic Vegetable*

Edisto REC
Jeremy Greene, *Field Crop Entomology*
Mike Marshall, *Field Crop Weeds*
Dan Anco, *Peanut Specialist*
John Mueller, *Field Crop Pathology*

Clemson Main Campus
Guido Schnabel, *Fruit Crop Pathology*
Juan Carlos Melgar, *Pomology*
Steve Jeffers, *Ornamental Crop and Tree Pathology*

UGA, Athens
Brett Blaauw, *Peach Entomologist*

Coordination Team
Francis Reay-Jones, *Program Coordinator*
Tim Bryant, *Associate Program Coordinator and Newsletter Editor*

Tell us what you think...

Please take a few minutes to fill out this survey to tell us what you would like to see in future editions of this newsletter!

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Host Plant Resistance Plays an Important Role in Managing Cotton Thrips

Contributing Authors: **Dr. Francis Reay-Jones, Dr. Jeremy Greene, and Sophia Conzemius**

Thrips choice and no-choice experiments conuducted on different cotton genotypes

Integrated pest management (IPM) emphasizes the value of using multiple control tactics to manage pests. While insecticides are valuable tools for growers and are important components of IPM programs, alternative management tactics can help to reduce the use of pesticides. This integrated approach can be essential when pests develop resistance to commonly used pesticides. This is the case with thrips, which are common insect pests of cotton early in the season. Thrips use piercing-sucking mouthparts to feed on young leaves, causing injury if enough thrips are present. If enough injury occurs, it can lead to severely stunted plants and result in yield loss or delays in maturity Management of thrips in cotton has traditionally relied heavily on the use of insecticides. However, the main pest species of thrips that can feed on cotton, tobacco thrips, *Frankiniella fusca*, has developed resistance to the most commonly used insecticides used for their management. Recently, Thryvon cotton has been developed as a genetically engineered trait to reduce infestations and injury from thrips and plant bugs. To complement this new transgenic trait and provide new management options for growers, research efforts at Clemson University with collaborators from the USDA-ARS and North Carolina State University have focused in recent years on exploring host plant resistance in cotton as a novel IPM tactic to address this issue.

"Host plant resistance can provide a more permanent solution to addressing insect pests," says Dr. Francis Reay-Jones, a field crop entomologist at Clemson's Pee Dee Research and Education Center. "The goal of this work is to explore untapped genetic diversity in exotic cotton landraces and identify genotypes that are naturally more resistant to thrips than our current commercial varieties – other than the new transgenic Thryvon trait, no commercial varieties have any resistance to thrips." Todd Campbell, USDA-ARS cotton breeder in Florence, SC and collaborator on this project found in the US National Plant Germplasm system a number of genotypes that are day-neutral, an essential characteristic in a cotton breeding program. This presented an exciting opportunity to explore these genetically diverse genotypes for potential resistance to thrips.

PhD entomology student Sophia Conzemius recently published a chapter of her dissertation on field trials with these exotic cotton landraces. "With over 1,000 plots in each field trial in North Carolina and South Carolina, it was a lot of work, but we were able to generate a lot of data. The challenge was how to summarize the data to identify which genotypes were resistant and which were susceptible," said Sophia. "To do this, we developed a new selection index that synthesized copious amounts of data across two years of study." As a follow-up to the field trials, Sophia conducted greenhouse and laboratory experiments at the Clemson University Edisto Research and Education Center to identify mechanisms of resistance. This might help explain why some genotypes are more resistant than others and can lead to finding ways to incorporate resistance... (cont. page 3)

into commercial cotton varieties, accelerating breeding efforts.

Based on the field data, a selection was made of resistant and susceptible cotton genotypes for further evaluation in the greenhouse. Choice and no-choice trials were conducted by releasing tobacco thrips in small cages in the greenhouse to measure attractiveness to and development of thrips on the genotypes. Through additional work with the Clemson Multi-user Analytical Laboratory and Metabolomic Core, the diversity and abundance of metabolites in the cotton genotypes was explored using an approach called metabolomics. This approach allowed the examination of a broad range of plant compounds that could potentially explain chemical mechanisms of resistance. Several metabolites were associated with resistance and might be useful as biomarkers in breeding programs making it easier for breeders to identify and select resistant plants.

By broadening our understanding of how thrips interact with cotton plants and by identifying genotypes with resistance to thrips, this work aims to advance our knowledge of insect biology and provide a more sustainable tool for IPM programs in cotton. Given the widespread insecticide resistance in tobacco thrips, this work provides a timely investigation into an environmentally friendly control tactic.

Female (left) and male (right) tobacco thrips

Nematode Management for 2023 Field Crops Starts Now

Contributing Authors: **Dr. John D. Mueller**

Typical nematode damage in corn. Non-treated plots (left) compared to nematacide-treated plots (right).

Nematodes are often overlooked in pest management schemes because of difficulties in identifying and quantifying their impact, but more than half of the row crop fields in South Carolina have significant levels of plant-parasitic nematodes. At least a third of corn, cotton and soybean fields have levels of plant-parasitic nematodes with the potential to cause at least a 10% yield loss. In many cases yield losses can be closer to 25% for fields under the right conditions. With nematode species such as root-knot, individual plant mortality is possible. However, severe damage is usually limited to smaller areas of the field.

There are three major tools available to combat yield losses due to nematodes in field crops. These include: 1). rotation to a nonhost crop; 2). planting a nematode-resistant variety; and 3). applying a nematicide. These would seem like simple options, but selection of the appropriate control measure is complicated by the fact that there are at least eight important species of nematodes that occur in South Carolina. Every field has its own profile of species present, ranging from none to all 10 of the important species. Determining what level of which species are present in each field is the... (cont. page 4)

key to cost-effective nematode management.

Dr. John Mueller, a field crop nematologist at Clemson's Edisto Research and Education Center, has done a large amount of research to develop strategies for growers to effectively identify, quantify, and manage nematodes in field crops.

"The first step in managing nematodes is to take nematode samples in every field where you feel your yields are not up to expectations and there are no other obvious causes" Dr. Mueller said. Yield maps are great ways to see these types of patterns. During the summer you can look for areas of stunted or discolored plants. Discolored plants damaged by nematodes are usually light green or reddish in color. These areas need to be sampled for nematodes. Soil samples can be collected and submitted through your county agent to the Clemson Nematode Assay Lab or through a consultant to a private laboratory. Samples should be taken as soon as possible after harvest to get the best estimate of nematode populations. This means that to develop a proper management scheme, nematode samples should be taken the previous fall. For example, take nematode samples in the fall of 2022 to create recommendations for crops planted in the spring of 2023. If you have never collected soil samples for nematodes, contact your county agent or consultant and let them walk you through the process. It is best to have all samples collected prior to Thanksgiving.

Nematode samples typically take several weeks to process. The results provided... (cont. page 5)

Nematode Common name (*Scientific name*)	**Corn**	**Cotton**	**Soybean**	**Peanut**	**Sorghum**
Southern root-knot (*Meloidogyne incognita*)	300	100	200	Non-host	?? [A]
Peanut root-knot [B] (*Meloidogyne arenaria*)	Poor host	Non-host	80	50+	?? NH
Soybean cyst (*Heterodera glycines*)	Non-host	Non-host	70	Non-host	Non-host
Reniform (*Rotylenchulus reniformis*)	Non-host	250	100	Non-host	Non-host
Columbia lance (*Hoplolaimus columbus*)	100	100	50	Non-host	50
Lesion (*Pratylenchus* spp.)	500	100	150	25	80
Sting (*Belonolaimus longicaudatus*)	4	10	4	8	4
Stubby root (*Paratrichodorus* spp.)	40	??	50	50	40
Ring (*Criconemella* spp.)	200	400	200	50	200
Spiral (*Helicotylenchus* spp. or *Scutellonema* spp.)	500+	800+	600+	250+	500+

Table 1. Threshold per 100ml of soil for samples taken in previous fall for major row crops and common nematodes in South Carolina.

[A] sorghums response to southern root-knot nematode caries greatly by soil texture, hybrid, and cropping history. The level of SKRN reproduction and damage can be high or low.

[B] two races of peanut root-knot nematode occur. race one goes to peanut and soybean, but race two only goes to soybean.

Nematode Common name (*Scientific name*)	**Corn**	**Cotton**	**Soybean**	**Peanut**	**Sorghum**
Southern root-knot (*Meloidogyne incognita*)	Host	Host	Host	Non-host	Host
Peanut root-knot (*Meloidogyne arenaria*)	Poor host	Non-host	Host/ nonhost	Host/ nonhost	Nonhost
Soybean cyst (*Heterodera glycines*)	Non-host	Non-host	Host	Non-host	Non-host
Reniform (*Rotylenchulus reniformis*)	Non-host	Host	Host	Non-host	Non-host
Columbia lance (*Hoplolaimus columbus*)	Host	Host	Host	Non-host	Host
Lesion (Pratylenchus spp.)	Host	Host	Host	Host	Host
Sting (Belonolaimus longicaudatus)	Host	Host	Host	Host/ nonhost	Host
Ring (Criconemella xenoplex)	Host	Host	Host	Host	Host
Stubby root (*Paratrichodorus* spp.)	Host	Host	Host	Host	Host
Spiral (Helicotylenchus & Scutellonema)	Host	Host	Host	Host	Host

Table 2. Host status of major row crops to common nematode species encountered in South Carolina.

Nematode Common name	Corn	Cotton	Soybean	Peanut	Sorghum
Southern root-knot	Rotation Nematicide	Rotation Resistance Nematicide	Rotation Resistance Nematicide	Non-host	Rotation Nematicide
Peanut root-knot	Poor host	Non-host	Host/ Nonhost	Rotation Resistance Nematicide	Rotation Nematicide
Soybean cyst	Non-host	Non-host	Rotation Resistance Nematicide	Non-host	Non-host
Reniform	Non-host	Rotation resistance Nematicide	Rotation Resistance Nematicide	Non-host	Non-host
Columbia lance	Rotation Nematicide	Rotation Nematicide	Rotation Nematicide	Non-host	Rotation Nematicide
Lesion	Nematicide	Nematicide	Nematicide	Nematicide	Nematicide
Sting	Nematicide	Nematicide	Nematicide	Nematicide	Nematicide
Ring	Nematicide	Nematicide	Nematicide	Nematicide	Nematicide

Table 3. Management options availible for commonly occuring nematode species on row crops in South Carolina

should tell you the density of each nematode species in each sample/ field. Table 1 gives you an indication of the number of each species that must be present to cause damage on each crop species the following crop year. For example, if you have 50 Columbia lance nematodes, they can cause a yield loss on corn, cotton, or soybean. However, as seen in Tables 1 & 2 peanut is not a host for Columbia lance nematode and can be planted in fields infested with Columbia lance nematode without fear of a yield loss. This illustrates the preferred method of controlling nematodes, which is to set up a crop rotation on your farm which rotates non-host crops through fields that contain damaging levels of a nematode species that does not affect them. A good example is controlling soybean cyst nematode by planting a nonhost such as corn or cotton. If you have soybean cyst nematode in a field, you want to avoid monocropping soybeans as that will lead to the buildup of this nematode species.

If crop rotation is not an option, in some cases an effective alternative or strategy to compliment rotation is planting a variety that is resistant to nematode injury. For example, there are soybean varieties that can be planted with resistance specifically to soybean cyst nematode. If you have a mixture of soybean cyst and Columbia lance nematodes, you may need to apply a nematicide to control Columbia lance nematode. It will also help control high levels of soybean cyst nematode on a resistant variety.

The tables provided in this article provide the host species, economic threshold levels, and effective control strategies for each nematode species in each crop. Table 1 indicates the economic injury level for each nematode/crop combination, Table 2 shows whether your crop is a host and will be damaged by a specific species of nematode, and Table 3 provides the possible control strategies. The scheme you develop should be set up for three- to five-year intervals but economics and logistics may force adjustments to the scheme over time.
For additional information on nematicide options and developing a long term rotation strategy consult with your local extension agent or reference Clemson's [field crop pest management handbook].

Symptoms of southern root-knot nematodes on soybeans (left) and corn roots (right).

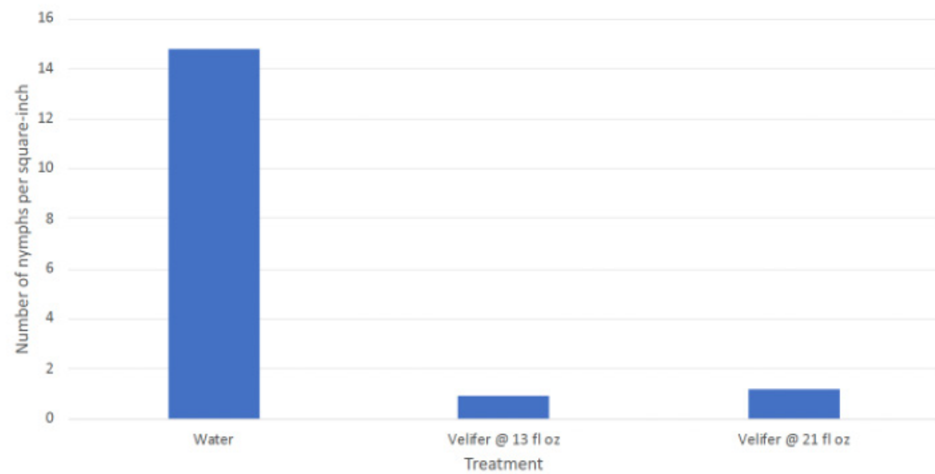
Start Clean, Stay Clean: Greenhouse Cutting Dipping as a Valuable Pest Management Tool

Contributing Authors: **Dr. JC Chong**

Sanitation is an important IPM strategy that should be part of every pest management plan. Sanitation includes properly cleaning and disinfecting growing spaces, proper crop and debris removal at season's end, regular and persistent weed removal, and much more.

The ultimate goal of sanitation is to minimize the starting population of pests or incidence/severity of diseases.

One major component of sanitation is ensuring that plant material entering the greenhouse, whether it be seed or transplants, are free of insect pests that could spread and thrive in your greenhouse. Dipping cuttings or liners (rooted or unrooted) in insecticide solution is a relatively new strategy that has shown great potential for reducing pest numbers on greenhouse ornamentals. Cuttings or liners are major pathways for introducing pests into a greenhouse. In one study, an initial infestation of 0.3 immature whiteflies per plant on just 1.2% of poinsettia cuttings resulted in 220 immature and 32 adult whiteflies per plant by the end of the crop cycle.



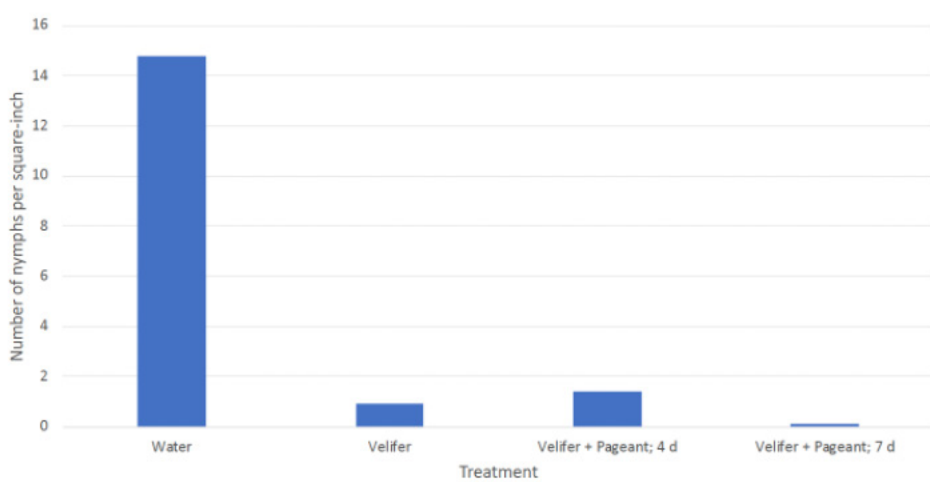


Figure 1 (top)*. number of whitefly nymphs per square inch of plant 8 weeks after insecticide dip and transplant with two rates of velifer*
Figure 2 (bottom). *number of whitefly nymphs per square inch of plant 8 weeks after insecticide dip and transplant, with fungicide treatments applied 4 days and 7 days post insecticide dip*

Cutting dips has been used in Canadian greenhouses for several years, but widespread adoption in the US greenhouses has been limited. Dr. JC Chong, an ornamental crop and turfgrass entomologist at Clemson's Pee Dee Research and Education Center, has made an effort to provide further evidence on the effectiveness of cutting dipping and promote its use in South Carolina. Dr. Chong refers to this strategy as "start clean and stay clean" as it relies on reducing or eliminating initial colonization's of insect pests to lessen the burden of managing these pests throughout the rest of the season. When pest populations are introduced and allowed to proliferate from cuttings and transplants, managing those pest populations when they explode later in the season can lead to pesticide resistance and a high level of residue that can limit the effectiveness of biological control.

One of the most common and damaging pests in the greenhouse are whiteflies. Limiting the introduction of whiteflies into the greenhouse is... (cont. page 7)

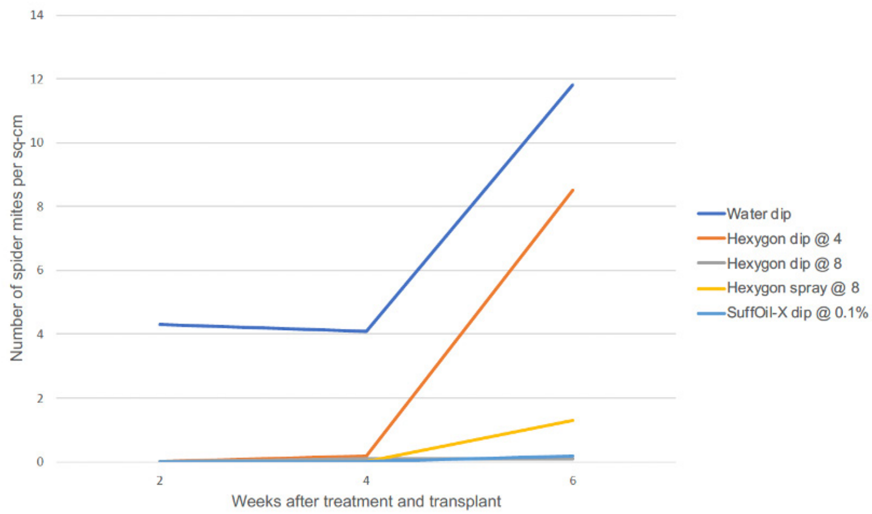


Figure 3. *Number of spider mites per square centimeter of plant 2, 4, and 6 weeks post insecticide dip and transplant using three rates of Hexygon and one rate of SuffOil-X*

critical for effective management. In a series of studies conducted from 2019 to 2021, Dr. Chong and his team tested several different products for dips targeting whiteflies on poinsettia cuttings. These treatments included Velifer (a newly introduced strain of the entomopathogenic fungus Beauveria bassiana) at two different rates, and M-Pede (insecticidal soap) combined with BotaniGard (a different and commonly used strain of Beauveria bassiana). Both treatments tested lead to a ~94% reduction in the numbers of whiteflies at eight weeks after treatment (figure 1). Dr. Chong's work led to label expansion of M-Pede for dipping cuttings.

Fungicides are commonly used during propagation and growing of cuttings to prevent root and stem rots. The fungicides may interfer with the efficacy of cutting dip treatment because, after all, the cutting dip treatment uses an entomopathogenic fungus. Dr. Chong and his team investigated if fungicide treatment applied during the rooting process may interfere with the efficacy of cutting dip treatment. The team treated poinsettia cuttings with dip of entomopathogenic fungi, and then treated the same cuttings with a fungicide four and seven days after dipping. Even with fungicide applications, the cutting dips in Velifer and BotaniGard were still highly effective in reducing whitefly populations eight weeks after dipping (figure 2). Results of this study suggested that cutting dip and fungicide treatment can be used in the same rooting process without detrimental effect to whitefly management.

Poinsettia cuttings being dipped in insecticide prior to tranplant

Whiteflies are not the only pests that can be introduced into the greenhouse via cuttings. Spider mites or thrips can also be commonly transported on plant materials and their initial populations can also be suppressed greatly by a cutting dip. Dr. Chong tested two different rates of Hexygon (hexythiazox, a miticide) and SuffOi-X (horticultural oil) dip for their efficacy against twospotted spider mites on marigold seedlings. The results of these studies showed that dipping marigolds for two-spotted spider mites was equally effective as dipping poinsettia for whiteflies (figure 3). These works led to label expansion of Hexygon and an pending label expansion of SuffOil-X for cutting dip.

The efficacy of dips will vary based on the plant, pest species, and rate of insecticide, but these studies show that it can be a very effective strategy to "start clean and stay clean." An... (cont. page 8)

important consideration when expanding this strategy to additional crops and insecticidal chemistries is potential phytotoxicity to different plant species. Additional studies are needed to expand the known breadth of applications for this strategy.

One of the major benefits of cutting dips is it can limit the use of insecticides later in the season. These later applications can negatively impact biological control agents, which are another component important to an IPM program in greenhouses. Cutting dipping studies in Canada showed that these treatments kept whiteflies at a level low enough for biological control agents to manage the remaining populations without additional insecticide application.

Additional information on dipping poinsettia cuttings can be found here. A video of how to dip cutting can be found here. See this previous IPM newsletter for a full overview of management strategies for whiteflies in the greenhouse.